SOME DATA RELATIVE TO THE RELATIONSHIP OF TEMPERATURE TO CODLING MOTH ACTIVITY[1]

BY THOMAS J. HEADLEE, PH.D.
ENTOMOLOGIST, NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS

ABSTRACT

Thermal constants for beginning emergence and maximum emergence of the overwintered generation and the first summer generation of codling moth, determined by summation of day degrees of effective temperature, exhibit a sufficiently small amount of variation from year to year to render them satisfactory indicators of time when insecticidal applications should be made for the control of the larvæ of that insect entering apples, but that the dates, as determined by the thermal constants, should be checked against the codling moth bait pan records in order to make sure that the season in question does not exhibit some unusual type of variation. While the dates of beginning emergence and maximum emergence of the overwintered generation and the first summer generation seem to vary according to the latitude and altitude phase of the bio-climatic law, the writer feels that further data should be secured before dependence is placed upon this principle for determining the dates of insecticidal applications. When the average weekly minimum temperature approaches 60° F. codling moth transformation from larva to pupa ceases. It is probable, however, that the determination of this tendency of larvæ to pupate occurs under a somewhat higher average minimum than 60° F. and it seems, in the writer's experience, that this determination of tendency takes place before the larva starts to spin its cocoon.

INTRODUCTION

The writer's general interest in the relation existing between temperature and insect activity, together with the pronounced advantage in the use of a thermal constant in practical codling moth control, first led him to undertake this study. The work of Mr. P. A. Glenn (1) on this subject further excited his interest because it indicated that the thermal constant might be used for the timing of insecticidal applications against the codling moth.

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The first question to be answered in the course of this study was—"Can the thermal constant be used as a practical and satisfactory indicator for the timing of insecticidal treatments against the codling moth?" The second question to be answered was—"Can the determination of the time of insecticidal treatments made at one point be extended to other regions of New Jersey through the operation of that phase of the bio-climatic law which relates to latitude and altitude?" The third question that this work was designed to answer was—"Is there anything in the temperature records which may be taken as an indicator that the transformation of codling moth larvæ will cease to occur for the balance of the season?"

Methods Used

The period covered by this study includes the following years and series of experiments: one series in 1919, one series in 1920, one series in 1921, one series in 1922, five series in 1926 and one series in 1927, making, all told, ten series in six years.

In every case codling moth larvæ were gathered from the tree trunks during the fall and winter. Each larva was placed in a small glass vial, stoppered with cotton or covered with a layer of cheesecloth. These vials were then placed upright in a screen-bottom box, painted white and hung on the branches of an apple tree in an orchard under observation. In the early experiments one hundred larvæ per box were used. In later experiments four hundred to five hundred larvæ per box were used. These larvæ were examined early enough in the spring to catch the first emergence and thereafter, until emergence ceased, they were examined at weekly intervals. Larvæ of the first generation were collected from the tree trunks as they descended, placed in glass vials and handled in precisely the same manner. Temperature records were secured in some cases from instruments kept in the orchard and in other cases from regular stations nearby. In the season of 1926 the records came directly from maximum and minimum thermometers, a set of which was placed in each orchard where a box of larvæ had been stationed.

The effective day degrees of temperature were computed on the basis of the formulæ found on page 283 of a publication (1).

TABLE 1

STUDY OF THE RELATION OF EFFECTIVE DAY DEGREES OF TEMPERATURE TO EMERGENCE OF HIBERNATING AND FIRST SUMMER GENERATIONS OF CODLING MOTH

Year	Place Name	Location		Begin Emergence	Accum. Temperature	Maximum Emergence	Accum. Temperature	End of Emergence	Accum. Temperature
		Latitude	Elevation Above Sea						
1919	Moorestown	40° 1″N.	75′	May 5	298.68	May 29	561.03	June 9	814.28
1920	Moorestown	40° 1″N.	75′	May 22	298.91	June 7	524.16	June 21	767.16
1921	Glassboro	39° 39″N.	130′	April 27	448.34	May 7	499.37	May 26	721.15
1922	Glassboro	39° 39″N.	130′	May 5	348.30	May 17	502.05	May 31	759.48
1926	Glassboro	39° 39″N.	130′	May 24	305.20	June 4	444.47	July 2	860.72
1927	Glassboro	39° 39″N.	130′	May 24	397.10	June 9	632.54	July 8	1252.39
1926	Pattenburg	40° 38″N.	700′	June 5	400.53	June 16	552.79	July 13	1162.17
1926	New Brunswick	40° 29″N.	110′	May 28	374.83	June 19	664.48	July 10	1088.45
1926	Riverton	40° 1″N.	15′	May 25	343.89	June 11	648.26	July 3	1055.32
1926	Bridgeton	39° 26″N.	90′	May 24	385.41	June 5	532.40	July 9	1205.28
Total for all years					3601.19		5561.55		9686.40
Average Thermal Constant					360.11		556.15		968.64

TABLE 1—(*Continued*)

STUDY OF THE RELATION OF EFFECTIVE DAY DEGREES OF TEMPERATURE TO EMERGENCE OF HIBERNATING AND FIRST SUMMER GENERATIONS OF CODLING MOTH

Year	Place Name	Location		Begin Emergence	Accum. Temperature	Maximum Emergence	Accum. Temperature	End of Emergence	Accum. Temperature
		Latitude	Elevation Above Sea						
1919	Moorestown	40° 1″N.	75′	July 7	1425.70	Aug. 2	2025.45	Aug. 30	2607.95
1920	Moorestown	40° 1″N.	75′	July 9	1138.66	July 27	1428.91	Aug. 26	2094.66
1921	Glassboro	39° 39″N.	130′	July 1	1450.53	July 18	1923.28	Aug. 14	2578.28
1922	Glassboro	39° 39″N.	130′	July 6	1562.48	July 26	2068.93	Aug. 26	2829.13
1926	Glassboro	39° 39″N.	130′	July 13	1122.22	July 30	1490.97	Aug. 27	....
1927	Glassboro	39° 39″N.	130′	July 15	1448.14	Aug. 5	1955.34	Sept. 19	2626.84
1926	Pattenburg	40° 38″N.	700′						
1926	New Brunswick	40° 29″N.	110′						
1926	Riverton	40° 1″N.	15′						
1926	Bridgeton	30° 26″N.	90′						
Total for all years					7967.73		10,892.88		12,736.86
Average Thermal Constant					1327.82		1,815.48		2,547.37

These computations were made by the junior clerk in the department office in order that no personal bias might enter into the results.

THE THERMAL CONSTANT STUDY

The summarized results of the thermal constant study are set forth in the following table:

For the purpose of comparing average results in thermal constants with similar studies in the state of Illinois, the writer is submitting Table No. 2.

TABLE 2

COMPARISON OF AVERAGE THERMAL CONSTANTS DERIVED FROM ILLINOIS AND NEW JERSEY

State	No. of Years Averaged	Accumulated Temperatures to Appearance of First Adults of Overwintered Generation	Accumulated Temperatures to Appearance of Adults of First Summer Generation
Illinois	3	340°	1342°
New Jersey	6	360.11°	1327.82°

Examination of these tables serves to show a remarkably close thermal constant for the appearance of the first adults of the overwintered and the first adults of the first summer generation as determined in two such widely separated areas as the state of Illinois and the state of New Jersey. It seems that this close correspondence may be taken to indicate that not only does such a thermal constant exist, but that variables, other than temperature, influence the emergence of codling moth to only a minor degree when the rainfall varies from 30 to 45 inches.

For the purpose of examining the extreme variation in thermal constants, resulting from the work in New Jersey, Table No. 3 is submitted.

Examination of this table serves to show that the percentage variation will average close to 30 per cent. or less for beginning and maximum emergence which are above all the critical indications. It therefore seems that in any one year the average thermal constant would not miss the extreme variation by more than about 15 per cent. If this variation be translated into days on the overwintered generation, the period of the phenomenon would not vary much more than a week while on the first summer generation it would vary only a few days.

Thus far the thermal constant seems to have a real and reliable existence and to show an amount of variation sufficiently small to render it rather practical for determination of the time of insecticidal applications against the codling moth.

TABLE 3

EXTREME VARIATION IN THERMAL CONSTANTS AS SHOWN IN NEW JERSEY WORK

Thermal Constants for Overwintered Generation								
Begin Emergence			Maximum Emergence			End Emergence		
Max.	Min.	Dif.	Max.	Min.	Dif.	Max.	Min.	Dif.
448.34	298.68	149.66	664.48	444.47	220.01	1252.39	721.15	531.24
Per cent. Variation		33			33			43

Thermal Constants for First Summer Generation								
Begin Emergence			Maximum Emergence			End Emergence		
Max.	Min.	Dif.	Max.	Min.	Dif.	Max.	Min.	Dif.
1562.48	1122.22	440.26	2068.93	1428.91	640.02	2829.13	2094.66	734.47
Per cent. Variation		22			30			25

Of course, the only satisfactory method of testing the application of the thermal constant as a determinator of time for insecticidal applications for the codling moth lies in its actual field employment. This phase of the investigation was undertaken in 1927 and the thermal constant was checked against emergence from the codling moth boxes and against adult moths caught in bait pans. The results are set forth in Table No. 4.

Examination of Table No. 4 shows that the emergence in numbers of the overwintered generation of codling moth in the boxes

TABLE 4

TEST OF THE APPLICATION OF A THERMAL CONSTANT AS A MEANS OF DETERMINING THE TIME WHEN INSECTICIDAL TREATMENTS SHOULD BE GIVEN FOR CODLING MOTH CONTROL

Date		Moth emergence		Moths caught in 10 bait pans		Larvæ entrance of fruit	Day degrees of accumulated temperature
		Moths emerged	Moths accumulated	Moths caught	Moths accumulated		
April	4/27						0.0
"	5						0.0
"	6						5.06
"	7						8.88
"	8						0.0
"	9						0.0
"	10						0.0
"	11						11.37
"	12						16.93
"	13						0.0
"	14						19.93
"	15						24.75
"	16						39.27
"	17						
"	18						51.06
"	19						62.10
"	20						85.85
"	21						103.10
"	22						105.10
"	23						105.87
"	24						0.0
"	25						107.71
"	26						111.78
"	27						114.44
"	28						118.38
"	29						124.0
"	30						0.0
May	1						129.82
"	2						137.05
"	3						151.12
"	4						164.37
"	5						176.37
"	6						188.12
"	7						199.87
"	8						206.87
"	9						220.87
"	10						242.87
"	11						260.12
"	12						269.87
"	13						276.25
"	14						285.10

TABLE 4—(*Continued*)

Date	Moth emergence		Moths caught in 10 bait pans		Larvæ entrance of fruit	Day degrees of accumulated temperature
	Moths emerged	Moths accumulated	Moths caught	Moths accumulated		
May 15						291.60
" 16						296.35
" 17						306.60
" 18						314.85
" 19						320.85
" 20	0	0				333.10
" 21			Bait pan placed			346.60
" 22						368.10
" 23						387.60
" 24			48	48		397.10
" 25						407.85
" 26						422.35
" 27	100	100	11	59		433.62
" 28						441.00
" 29						454.62
" 30						471.12
" 31			170	229		485.12
June 1						495.46
" 2			46	275		508.54
" 3	191	291	71	346		522.29
" 4						541.54
" 5			51	397		559.79
" 6						575.04
" 7			159	556		589.79
" 8						607.79
" 9			49			632.54
" 10	285	576		605		662.29
" 11			91	696		689.04
" 12						713.29
" 13			127	823		722.04
" 14						726.54
" 15			24	847		737.79
" 16						749.79
" 17	298	874	101	948	Entry noticeable	762.54
" 18						777.54
" 19						791.54
" 20						821.54
" 21			130	1078		847.29
" 22						874.54
" 23						900.04
" 24	120	994	76	1154		934.29
" 25						966.54
" 26						996.04
" 27			66	1220		1017.54
" 28						1035.54
" 29			240	1460		1061.04
" 30						1084.04

TABLE 4—(*Continued*)

Date	Moth emergence		Moths caught in 10 bait pans		Larvæ entrance of fruit	Day degrees of accumulated temperature
	Moths emerged	Moths accumulated	Moths caught	Moths accumulated		
July 1	43	1037	97	1557		1105.79
" 2						1125.79
" 3						1148.79
" 4						1169.54
" 5			70	1627		1186.36
" 6						1201.64
" 7			44	1671	Entry ceased	1226.14
" 8	4	1041				1252.39
" 9			6	1677		1277.14
" 10						1299.39
" 11			3	1680		1324.14
" 12						1350.39
" 13			0			1382.14
" 14						1415.14
" 15	7		5	5		1448.14
" 16						1480.64
" 17						1509.89
" 18			0			1537.64
" 19						1558.39
" 20			1	6		1581.39
" 21						1604.14
" 22	158	165	0		No new entry	1623.14
" 23						1645.14
" 24			1	7		1667.39
" 25						1688.64
" 26			1	8		1713.64
" 27						1739.64
" 28			5	13		1766.39
" 29	197	362				1795.89
" 30						1826.14
" 31						1852.34
Aug. 1			1	14		1877.34
" 2						1900.59
" 3						1918.09
" 4			7	21	Abundance of new entry	1932.59
" 5	163	525				1955.34
" 6						1975.34
" 7						1998.84
" 8			13	34		2025.09
" 9						2053.34
" 10			24	58		2073.59
" 11						2090.84
" 12	182	707	36	94	New entry present but scarce	2110.84
" 13						2133.59
" 14						2155.34
" 15			12	106		2176.34
" 16						2198.59

Table 4—(*Continued*)

Date	Moth emergence		Moths caught in 10 bait pans		Larvæ entrance of fruit	Day degrees of accumulated temperature
	Moths emerged	Moths accumulated	Moths caught	Moths accumulated		
Aug. 17			18	124		2211.09
" 18						2225.34
" 19	67	774	10	134		2239.84
" 20						2254.09
" 21						2271.09
" 22						2289.59
" 23			40	174	New entry continuing slowly	2307.04
" 24						2326.34
" 25			22	196		2341.59
" 26	71	845				2356.09
" 27						2371.84
" 28						2382.09
" 29			16	212		2397.34
" 30						2415.34
" 31						2434.34
Sept. 1						2454.34
" 2	31	876				2476.09
" 3						2497.34
" 4						2524.59
" 5						2547.34
" 6						2567.34
" 7			25	237	New entry continues	2586.34
" 8						2605.84
" 9	19	895				2626.84
" 10			3	240		2641.84
" 11						2662.34
" 12						2679.84
" 13			1	241	New entry continues	2693.09
" 14						2708.84
" 15			3	244	New entry ceased	2735.34
" 16	0					2760.34
" 17			0			2779.09
" 18						2799.34
" 19						2818.84
" 20			0			2835.59
" 21						2848.34
" 22						2858.99
" 23	0		0			2870.25
" 24						2880.04
" 25			0			2886.80
" 26						2898.52
" 27			0			2911.23
" 28						2920.70
" 29						2938.20
" 30						2961.20

began on some date lying between May 20 and May 27. Judging from the numbers found on May 27 it is probable that emergence began closer to May 20 than to May 27. On May 21 the accumulated day degrees of effective temperature were 346.60, while one day later the accumulated temperatures were 368.10. It seems, therefore, that the average thermal constant, as shown from the New Jersey work (360.11°) and from the Illinois work (340.0°), pretty nearly coincides with the actual accumulation shown in New Jersey by the records of 1927.

Examination of Table No. 4 shows that maximum emergence of the overwintered generation occurred shortly preceding June 10, on which date there was an accumulation of 662.29 day degrees of effective temperature. It is probable that the maximum emergence was reached on June 9, when the day degrees of effective temperature accumulation were 632.54. When we consider that the average thermal constant for this phenomenon, as set forth in Table No. 1, was 556.15°, the variation (76.39°) is very small, being accumulated within a period of four days or less.

Examination of Table No. 4 shows that the end of emergence of the overwintered generation of codling moth came about July 8, when there was an average accumulation of 1,252.39 day degrees of effective temperature. The average thermal constant for this phenomenon, as set forth in Table No. 1, was 968.64°, a difference of 283.75°, which would have been accumulated in a period of about twelve days. Obviously the correspondence between the average thermal constant and the actual accumulated day degrees of effective temperature shows, in this case, much greater variation than in either of the other two cases.

Examination of Table No. 4 shows that emergence of the first summer generation of codling moth began in the boxes shortly previous to July 15, when an accumulation of 1,448.14 day degrees of effective temperature had occurred. The average thermal constant for this phenomenon, as set forth in Table No. 1, is 1,327.82°, or a difference of 120.32°, which was accumulated in 1927 in a period of about four days.

Examination of Table No. 4 shows that maximum emergence of the first summer generation of codling moth occurred in the boxes about August 2, when there had been an accumulation of 1,900.59 day degrees of effective temperature. The thermal constant for this phenomenon, as set forth in Table No. 1, is 1,815.48°, or a difference of 85.11°, which was accumulated in 1927 within about three and a half days.

Examination of Table No. 4 shows that the end of the emergence of the moths of the first summer generation came on September 9 when there had been an accumulation of 2,626.84 day degrees of effective temperature. The thermal constant for this phenomenon, as set forth in Table No. 1, is 2,547.37°, or a difference of 79.47°, which was accumulated in 1927 within four days.

In summarizing the correspondence between the average thermal constant determined by six years and ten series of experiments and the actual accumulated day degrees of effective temperature in 1927 it may be said: (1) that the variation of the actual date of beginning emergence of the overwintered generation of codling moth in 1927 from the date indicated by the average thermal constant does not exceed two days; (2) that the variation of the actual date of the occurrence of maximum emergence of the overwintered generation of codling moths in 1927 from the date indicated by the average thermal constant does not exceed four days; (3) that the variation between the actual date of the ceasing of emergence of the overwintered generation of codling moth in 1927 from the date indicated by the average thermal constant does not exceed twelve days; (4) that the variation of the date of beginning emergence of the first summer generation of codling moth in 1927 from the date for that phenomenon, as indicated by the average thermal constant, does not exceed four days; (5) that the variation of the actual date on which occurred the maximum emergence of the first summer generation of codling moth in 1927 from the date as indicated by the average thermal constant does not exceed three and a half days; (6) that the variation of the actual date on which occurred the end of emergence of the first summer generation of codling moth in 1927 from the date of that phenomenon, as indicated by the average thermal constant, does not exceed four days.

Naturally, there would exist in the reader's mind a question as to whether the codling moth box records correctly represent that which has occurred in the orchard where the box has been placed. In order to check up this phase of the question, there is set forth in Table No. 4 the catches of codling moth on the wing which occurred in the bait pans. All told, of the overwintered generation, 1,680 specimens of adult codling moth were caught in bait pans. The catch began during the week existing between May 20 and May 27, thus definitely placing the beginning of moths on the wing within that week and indicating that possibly it may have begun a little earlier. The maximum emergence of the overwintered generation of the codling moth occurred shortly preceding June 10, while the maximum catch in the bait pans occurred on June 15 or five or six days later. The end of the emergence of the overwintered generation came on July 8 and the end of the bait pan catch came on July 11 or three days later. The beginning of the emergence of the first summer generation of codling moth in the boxes occurred shortly previous to July 15, while the first catch of this brood in the bait pans occurred either July 15 or July 20. This uncertainty concerning the identity of the bait pan catch is due to the fact that the five specimens caught July 15 might possibly be a hang-over. The maximum emergence of the first summer generation of codling moths occurred in the boxes about August 2 while the maximum catch of this brood in the bait pans arrived about August 17 or about two weeks later. The end of emergence of the first summer generation of codling moth occurred in the boxes on September 9 while the end of bait pan collections occurred on September 15 or a little less than one week later.

This correspondence between the bait pan record and the codling moth emergence in the boxes seems adequately to bear out the notion that the phenomena of beginning, reaching maximum, and ceasing emergence of both broods rather satisfactorily reports that which is occurring in the orchard. The only important difference seems to lie in the fact that the bait pan record indicates a beginning emergence in the orchard somewhat earlier than that which occurred in the boxes.

A further indication of the relation of emergence in codling moth boxes to that which actually occurs in the orchard is indicated in Table No. 4 in the column devoted to entry of the fruit by codling moth larvæ.

Disregarding the blossom fall spray the time of which is absolutely determined by the development of the apple tree, it may be said that sprays for codling moth must be upon fruit and foliage when the larvæ are hatching, crawling upon the foliage, and trying to enter the fruit. Where infestation in unsprayed trees will not exceed 50 per cent. of the apples, it has been found in practice that one cover spray for the first brood and one cover spray for the second brood serves to effect a satisfactory degree of control and that accurate timing of these sprays is a matter of high importance. It has been the common practice in New Jersey for many years, under these conditions, to recommend the application of the first cover spray immediately after the maximum emergence of the overwintered generation has occurred in the codling moth boxes. Examination of Table No. 4 will serve to show that the application of the first cover spray would have begun June 9 or 10 and would have been completed within six or seven days. The first entry noticeable was discovered on the seventeenth day of June and was not, at that time, even the oldest examples, more than two days old. Thus it appears that the time of this cover spray would have been correct. In past years, in making a timing recommendation for the cover spray for the second brood of larvæ, it was customary to advise the same to begin just before the maximum emergence of the first summer generation had taken place. This would have meant in 1927 that the cover spray would have started July 29 and would have been completed within a week. Examination of Table No. 4 shows that new entry was abundant on August 4, indicating that the timing of this spray, on the basis of the codling moth box, would have been satisfactory.

In regions where the codling moth will infest more than 50 per cent. of the apples borne on unsprayed trees, experience has shown that the cover spray applications for the first brood of larvæ must begin shortly before entry of the fruit starts and be repeated often enough to maintain a thorough coating of fruit and foliage until entry by the first brood of larvæ ceases. On this basis in 1927 cover sprays should have begun June 9, should have been repeated about June 19 and again on June 29, thus preserving an anti-codling moth coating throughout the period of entry by larvæ of the first brood, under conditions of rainfall such as existed in that year. In timing treatments for the second brood of codling moth larvæ, if any are deemed necessary, cover sprays in 1927 should have begun about July 29 and should have been repeated about August 12. As a matter of fact, experience shows that if three cover sprays are properly given for the first brood there is little need of further spraying during the balance of the season.

Thus we see that the average thermal constant may be used as an indicator of the time when anti-codling moth sprays should be applied for both the first and the second broods of larvæ and that the bait pan records afford a very desirable check up on the data offered by the thermal constant. In timing spray operations against codling moth in New Jersey in 1928, twenty-five to thirty sets of maximum and minimum thermometers will be placed in strategic orchards in different parts of the state. Likewise, in each of these orchards a group of ten bait pans will be maintained. The records will be forwarded to the central office and, on the basis of this data, an attempt will be made to determine the proper treatment dates for the entering codling moth larvæ of the first and second broods. It is not anticipated, however, that it will be necessary to continue spray applications for the second brood, providing cover sprays for the first brood are adequately maintained.

Extension of the Use of Thermal Constants from Areas in which Thermometers and Bait Pans are Located to Other Areas

If the data obtained on the thermal constant at one or more points can be extended to other points where the thermometer and bait pan records are not taken, with our present knowledge it will have to be done through the utilization of that phase of the bioclimatic law which deals with latitude and altitude. In 1926 stations were maintained at six different points in the state. The latitude and altitude of these points were secured from the records and the theoretic difference in days worked out for a comparison with the actual difference in days. Table No. 5 will serve to set forth the results.

TABLE 5

APPLICATION OF THE BIOCLIMATIC LAW TO CODLING MOTH EMERGENCE IN NEW JERSEY IN 1926

Place	North Latitude	Altitude in feet	Theoretic Difference in Days	Actual Difference in Days Begin Emergence
Glassboro	39° 39″	130		
Pattenburg	40° 38″	700	9.63	12
New Brunswick	40° 29″	110	3.13	4
Riverton	40° 1″	15	0.31	1
Bridgeton	39° 26″	90	1.26	0

Examination of this table indicates that the bioclimatic law does approximately apply to the occurrence of the beginning of emergence of the overwintering generation of codling moth in the areas where the study was made. Although the correspondence is reasonably close, it is felt, however, that further confirmative data should be available before the operation of this law is depended upon for the timing of spray applications.

RELATION OF THE LATE SUMMER AND EARLY FALL TEMPERATURE RECORD TO THE TIME WHEN CODLING MOTH LARVÆ CEASE TO TRANSFORM TO PUPÆ

In 1927, beginning on July 8, regular weekly collections of larvæ were made. In each collection the percentages of larvæ and of pupæ were determined. The moth emergence from each collection was also checked up. The minimum temperatures of the week, ending on date of collection, have been averaged and introduced in the table for purposes of comparison. The results are set forth in Table No. 6.

Examination of Table No. 6 shows that all pupation ceased in the week ending August 12, when the average minimum temperature was 61.4° F., indicating that pupation ceases as the weekly minimum average approaches 60° F. The writer believes that the initiating weekly average temperature is somewhat higher

TABLE 6

PUPATION AND EMERGENCE FROM CODLING MOTH LARVÆ COLLECTED AT GLASSBORO IN 1927

Date of Collection	Per cent. Larvæ	Per cent. Pupæ	Per cent. Moth Emergence	Average Minimum Temperature
July 8, '27	90	10	100.0	
" 15	70	30	100.0	70.2
" 22	40	60	96.1	67.4
" 29	30	70	95.5	66.2
Aug. 5	50	50	67.2	64.0
" 12	75	25	20.5	61.4
" 19	90	10	10.0	58.8
" 26	90	10	7.7	58.5
Sept. 2	98	2	0.0	58.7

because his experience indicates that the tendency to pupate or to overwinter has been determined before the cocoon is spun.

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